The MacroAlgaeBiorefinery – sustainable production of 3G bioenergy carriers and high value aquatic fish feed from macroalgae [MAB3]

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Worldwide, researchers work to combat the increase of carbon in the form of CO2 in the atmosphere and excess of nutrients - in particular nitrogen and phosphorus - in our aquatic environment - both "pollutants" being the consequence of human activities. However, nitrogen and phosphorus serve as essential nutrient components for the growth of terrestrial and aquatic plants, which are needed for the production of food, feed, and for future energy carriers. In this project, an integrated biorefinery concept have been developed for conversion of two carefully selected (based on their sugar and amino acid composition) candidates of brown macroalgae, i.e. *Saccharina latissima* and *Laminaria digitata* into energy carriers (ethanol, butanol, and methane), and a protein and lipid enriched fish feed derived as a residual from the energy conversion processes. The macroalgae are cultivated on lines, using emissions from land-based activities as a resource for growth. The offshore cultivation system constitutes as such a turnkey green-engineered system transforming linearity into a circular nutrient management system. The system is mimicking the natural system delivering bioremediation, i.e. water quality restoration, through nutrient cycling (supporting services) and climate change mitigation services through assimilation of fossil CO2/HCO3- (regulating service). The biomass obtained through capturing CO2 from the atmosphere and anthropogenic nutrients from eutrophied coastal seawater is used as a feedstock for biorefinery of two brown algae into three energy carriers - bioethanol, biobutanol and biogas - and a high-protein fish feed supplemented with essential amino acids (provisional services). Life cycle sustainability and feasibility assessment of the industrial ecology system have documented the environmental, social and economic performance of macroalgae production and biorefinery system.